Lecture Module - Sensors

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering

Tennessee Technological University

Module 4 – Sensors

Module 4 - Sensors

- Topic 1 - Introduction and Overview
- Topic 2 - IC and MEMS based Sensors

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
Example 2: Rotation
Example 3: Orientation

Topic 1 - Introduction and Overview

- Analog and Digital Sensors

- Example 1: Distance or Range

- Example 2: Rotation

- Example 3: Orientation

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
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Analog and Digital Sensors

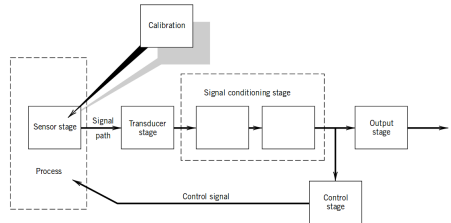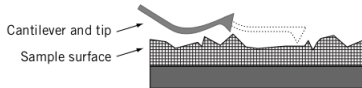a sensor, a physical element that employs some natural phenomenon... ...to sense the variable being measured

Figure 1.5 Components of a general measurement system.

Image: Theory and Design of Mech. Meas.

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
Example 2: Rotation
Example 3: Orientation

Analog and Digital Sensors

Sensors are typically classified as either **analog** or **digital** based on the type of signal that is output from the sensor.

However, this can be a misleading term. Many digital sensors operate based on analog circuit principles but require a digital circuit or MCU to operate or comminicate.

Analog	Digital	Both?

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
Example 2: Rotation
Example 3: Orientation

Analog and Digital Sensors

Other Classifications:

- Contact vs Non-Contact
- Programmable (Configurable) vs Non-Programmable
- By Measured Variable

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
Example 2: Rotation
Example 3: Orientation

Example 1: Distance or Range

Thought Exercise: How do we measure distance (aka range)?

- What variable or quantity is used to describe distance?
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- What type of sensor is used to measure this?
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Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
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Example 1: Distance or Range
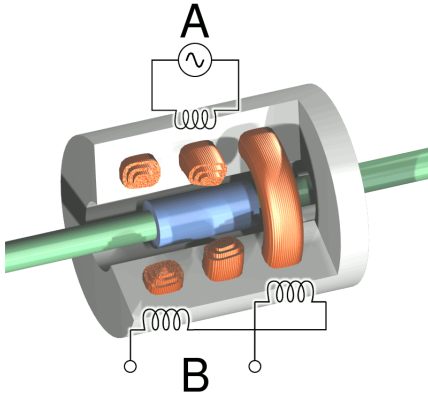
LVDTs with NI
LVDT Animation

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Example 1: Distance or Range

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Analog and Digital Sensors
Example 1: Distance or Range
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Example 3: Orientation

- What applications require this type of sensor?

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Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
Example 2: Rotation
Example 3: Orientation

Example 3: Orientation

- How does this type of sensor work?

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Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
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Example 3: Orientation

Example 2: Rotation

Thought Exercise: How do we measure rotation?

- What variable or quantity is used to describe rotation?
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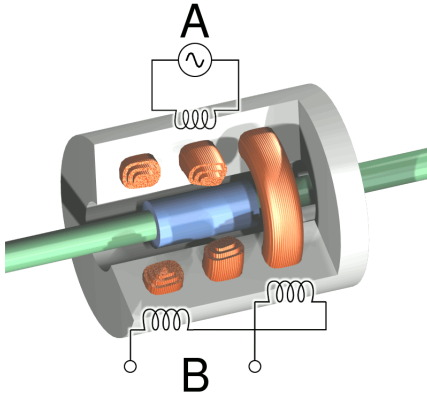- What type of sensor is used to measure this?
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Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
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Example 2: Rotation

Rotational Potentiometer

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
Example 1: Distance or Range
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Example 3: Orientation

Example 2: Rotation

Absolute Encoder

Introduction and Overview
IC and MEMS based Sensors

Analog and Digital Sensors
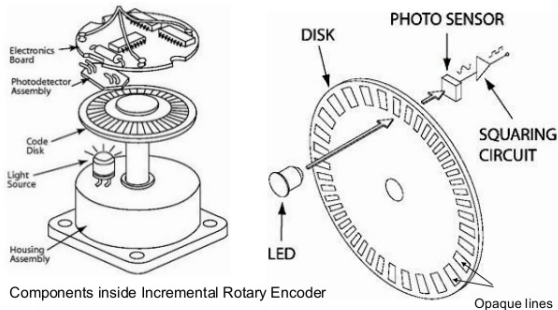Example 1: Distance or Range
Example 2: Rotation
Example 3: Orientation

Incremental Encoder

2. Types of Rotary Encoder - Incremental

Construction of Incremental Rotary Encoder

Components inside Incremental Rotary Encoder

Introduction and Overview
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Example 2: Rotation

- What applications require this type of sensor?

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Example 2: Rotation

- How does this type of sensor work?

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Analog and Digital Sensors
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Example 3: Orientation

Thought Exercise: How do we measure orientation?

- What variable or quantity is used to describe orientation?
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- What type of sensor is used to measure this?
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Example 3: Orientation

ADD EXAMPLE ORIENTATION SENSOR HERE

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Example 3: Orientation

- What applications require this type of sensor?

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- How does this type of sensor work?

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Introduction and Overview
IC and MEMS based Sensors

Integrated Circuits
Micro Electro-Mechanical Devices
Example 1: Magnometer and Digital Compass
Example 2: Accelerometer

Topic 2 - IC and MEMS based Sensors

- Integrated Circuits

- Micro Electro-Mechanical Devices

- Example 1: Magnometer and Digital Compass

- Example 2: Accelerometer

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Integrated Circuits

Actvitity: Group Brainstorming
List three applications or devices that use IC based sensors.

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Integrated Circuits

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Micro Electro-Mechanical Devices

Actvitity: Group Brainstorming List three sensors that are found on a high performance quadcopter or drone.

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Micro Electro-Mechanical Devices

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Example 1: Magnometer and Digital Compass

An accelerometer is a tool that measures proper acceleration, which is the acceleration of a body in its own instantaneous frame.
Applications:

- Navigation Systems - Robotics - Aircraft - Missiles
- Personal Devices - Phones - Tablets
- Others:

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Example 1: Magnometer and Digital Compass

Thought Exercise: How do we measure acceleration?

Actvitity: Group Brainstorming
Explain one method for measuring acceleration of a body.

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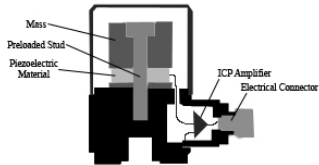
Example 1: Magnometer and Digital Compass

Mechanical Accelerometers Consist of a damped mass spring system and a sensing device.
Types of accelerometers:

- Seismometer or Seismograph
- piezoelectric - charge in material resulting from mechanical stress
- piezoresistive - change in resistance resulting from mechanical stress
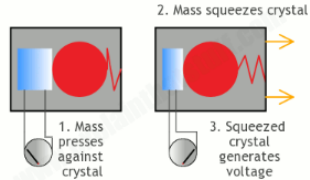- capacitive

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Example 1: Magnometer and Digital Compass

piezoelectric accelerometer

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Example 1: Magnometer and Digital Compass

capacitive accelerometer

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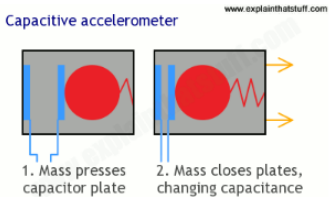
Example 2: Accelerometer

Thought Exercise: How do we measure orientation?

- What variable or quantity is used to describe motion?

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  -

- What type of sensor is used to measure this?

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Example 2: Accelerometer

- What applications require this type of sensor?

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Example 2: Accelerometer